FINISHING METHOD FOR STEPPING MOTOR STATOR STACK AND ROTOR STACK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims all rights of priority to Japanese Patent Application No. 2002-244433 filed on August 26, 2002 (pending).

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a finishing method for stepping motor stator stacks and rotor stacks, and more specifically to a finishing method for eliminating burrs remaining on the small tooth surface of stator stacks and rotor stacks after abrasive finishing by means of a mechanical process without loss of the original shape of the small teeth.

[0003] Stepping motor stators are formed by turning, stacking and laminating a plurality of magnetic steel plates formed with a plurality of magnetic pole parts at equal intervals oriented toward the central axis of the motor. Each of the plurality of magnetic pole parts in the steel plates has a plurality of small teeth formed at its tip at equal intervals in the direction of the circumference and oriented toward the central axis of the motor, and by laminating a plurality of such magnetic steel plates, the plurality of small teeth form long, narrow protrusions and long, narrow grooves between adjacent protrusions.

[0004] In a state where a stator stack of this sort has only undergone abrasive finishing by means of a mechanical process, burrs or rough areas that arise in the process of punching for forming or stamping this shape in the magnetic steel plates remain. Furthermore, after the plurality of magnetic steel plates have been turned,

stacked and laminated, the irregularity in the inside diameter is eliminated by means of stacking. However, processing burrs remain on the small tooth surfaces of each magnetic steel plate because of the honing process carried out to assure the roundness.

[0005] Conventional methods consisted of spraying beads from a blaster and brushing in order to eliminate these trimming burrs and processing burrs remaining on the small teeth of each of the laminated plates of the stator stack.

[0006] Unfortunately, these methods for removing burrs have the following problems.

[0007] Specifically, in the method of spraying beads from a blaster it is difficult to uniformly eliminate the burrs remaining on the small tooth surfaces because of the orientation of the bead spray and the distance between the small teeth and the spray nozzle. Additionally, the removed burr dust and the beads fall into the spaces between the plural laminated steel plates and cannot easily be removed by cleaning. Subsequently, these removed burrs can cause poor rotation of the motor by lodging between the stator and the rotor.

[0008] Furthermore, in order to avoid a lack of uniformity in the removal by brush abrasion in the brushing method, the brushes must be moved back and forth in the direction of the small tooth stacks to remove the burrs. Additionally, if the brush replacement frequency is not managed appropriately, removed burrs and abrasion dust from the brushes can lodge in the spaces between the plural laminated plates. Additionally, it is not easy to eliminate these particles through cleaning, they can cause poor rotation of the motor by lodging between the stator and the rotor.

[0009] Next, a stepping motor rotor stack is formed by laminating a plurality of round magnetic steel plates where a plurality of small teeth has been formed on the perimeter at equal intervals oriented toward the perimeter. By laminating a plurality of such magnetic steel plates, long, narrow protrusions are formed through the stacking, and long, narrow grooves are formed between adjacent protrusions.

[0010] In a state where a rotor stack of this sort has only undergone abrasive finishing by means of a mechanical process, burrs that arise in the process of punching for forming or stamping this shape in the magnetic steel plates remain. Furthermore, after the plurality of magnetic steel plates have been laminated, the irregularity in the outside diameter is eliminated by means of laminating. However, processing burrs remain on the small tooth surfaces of each magnetic steel plate because of the grinding process carried out to assure the roundness.

[0011] Conventional methods consisted of spraying beads from a blaster, buffing and brushing in order to eliminate these trimming burrs and processing burrs remaining on the small teeth of each of the laminated plates of the rotor stack.

[0012] Unfortunately, these methods for removing burrs have the following problems.

[0013] More specifically and as mentioned above, the method of spraying beads from a blaster and the method of brushing have the same problems observed for methods on stator stacks. Furthermore, the components of the buffer in the method of buffing become lodged in between the layers of the plural laminated steel plates and cannot be easily eliminated by cleaning. Subsequently, these removed burrs can cause poor rotation of the motor by lodging between the stator and the rotor. Even if

elimination of these particles was possible, a great amount of time would be needed to do so.

[0014] As mentioned above, all of these conventional methods for eliminating trimming and processing burrs present problems. These burrs still remain on the small tooth surfaces of stepping motor stator stacks and rotor stacks that have been abrasively or finally finished by means of honing, grinding and other mechanical processes. Moreover, since all of these methods are ones where contact is made with the small teeth, difficulties arise in eliminating burrs without dulling these teeth. Other notable problems are having to suitably adjust and change the relative speed of rotation, the relative orientation of the motion of the jig, work and pressure used on the work at the appropriate time, the difficulty in managing these working conditions and the long processing time.

SUMMARY OF THE INVENTION

[0015] The present invention was conceived to solve the problems of the prior art described above and its object is to provide a stepping motor stator stack and rotor stack finishing method that uniformly eliminates the burrs remaining on the small tooth surfaces of both stacks without causing dulling of the small teeth, and further prevents the removed burrs from lodging in the spaces in the laminates between the plural steel plates that form both stacks, prevents flying out during motor rotation and also lodging between the stator and rotor therefore allowing proper rotation of the motor.

[0016] The present invention relates to a finishing method for stepping motor stator stacks and rotor stacks that solves the problems previously mentioned. When a finishing process is carried out on stepping motor stators that have undergone abrasive

finishing by means of a mechanical process to remove burrs, such as trimming burrs and processing burrs, left on the small tooth surfaces after processing, a high pressure liquid jet spray nozzle is inserted in the central cylindrical cavity of the stator stack, and while the spray nozzle is moved relatively along the central axis of the central cylindrical cavity and rotated relatively centered on the central axis of this cavity, the high pressure liquid jet sprayed from the jet orifices of this spray nozzle faces the central cylindrical cavity and hits the small tooth surfaces of the stator stack.

[0017] The trimming and processing burrs can be effectively dislodged, sent flying and removed by the strong force of impact of this high pressure liquid jet. Furthermore, the waste, oils, metal dust and crystalline material adhering to the small teeth can be effectively blown away and the small teeth cleaned. Also, since there is nothing to cause dulling of the small teeth, there is no fear of distorting the motor rotational characteristics.

[0018] The above advantages and features are of representative embodiments only. It should be understood that they are not to be considered limitations on the invention as defined by the claims. Additional features and advantages of the invention will become apparent in the following description and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] A full understanding of the invention can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

[0020] Fig. 1 is a vertical cross sectional view in the upper half and side view in the lower half of a stepping motor stator stack finishing method according to a first embodiment of the present invention.

[0021] Fig. 2 is a vertical cross sectional view of the same stator stack, showing the state where finishing is being carried out.

[0022] Fig. 3 is a frontal view of the same stator stack and at the same time a frontal view of one of the stacked steel plates forming the stator stack, showing the state where finishing is being carried out.

[0023] Fig. 4 is an enlargement of part of Fig. 3, showing the detailed structure of the small tooth part of one of the stacked steel plates forming the same stator stack.

[0024] Fig. 5 is a vertical cross sectional view in the upper half and side view in the lower half of a stepping motor rotor stack finishing method according to a second embodiment of the present invention.

[0025] Fig. 6 is a frontal view of the same rotor stack and at the same time a frontal view of one of the stacked steel plates forming the rotor stack, showing the state where finishing is being carried out.

[0026] Fig. 7 is an example of a variation of Fig. 6.

[0027] Fig. 8 is an enlargement of part of Fig. 6, showing the detailed structure of the small tooth part of one of the stacked steel plates forming the same rotor stack.

DETAILED DESCRIPTION

[0028] This invention solves the problems of prior art by providing a stepping motor stator stack and rotor stack finishing method that uniformly eliminates the burrs remaining on the small tooth surfaces of both stacks.

[0029] In accordance with a first embodiment of the present invention, in the stepping motor 1, the stator stack 4 is held between a front flange 3a and a rear flange 3b, each of which is cast as a unit with a front mold 2a and a rear mold 2b, respectively, which are a part of the walls on each end in the axial orientation, as is shown in Fig. 1. Further, a rotor stack 6 is housed in the central cylindrical cavity 5 of stator stack 4 which is formed by the front and rear molds 2a and 2b and the stator stack 4. Shaft 7 that rotates the rotor stack 6 is supported by two round holes in the front and rear molds 2a and 2b through front and rear bearings 8a and 8b.

[0030] In front of the front flange 3a, a protective plate 9 is attached through bushing 10. The front and rear flanges 3a and 3b, the stator stack 4 and the protective plate 9 are solidly connected by bolts 11 through their four corners and assembled into a unit. The rotating shaft 7 extends further than the protective plate 9, and the output of the stepping motor 1 is transferred to the load side through a gear 12 affixed to it.

[0031] The plurality of magnetic poles 13 as shown in Figs. 1 and 3, on the stator stack 4 are wound with magnetic field windings 14. A controlled electric current is supplied to these magnetic field windings through connectors 15, leads 16 and a control circuit 17. A coil spring 23 is disposed between the rotor stack 6 and the rear bearing 8b, such that the rotor stack 6 always generates a rotational force by means of the launching force of the coil spring 23.

[0032] The structure of the stator 4 will be described in further detail.

[0033] As shown in Figs. 1 to 4, the stator stack 4 is formed from the turning, stacking and laminating of a plurality of steel plates 4a made from a magnetic material. A plurality of T-shaped magnetic pole parts 13a are formed at equal intervals around the circumference oriented toward the central axis, that is, the axis of the rotating shaft 7. A plurality of small teeth 18 are oriented toward the central axis of the stepping motor 1 and formed at equal intervals around the circumference on the wide part of the head of the T on each of the plurality of magnetic pole parts on these laminated steel plates 4a.

[0034] These plural magnetic pole parts 13a are stacked and form a T-shaped magnetic pole 13 as viewed straight from the front through the laminating of a plurality of these stacked steel plates 4a, and a space 19 is formed for wrapping the magnetic field windings 14 between adjacent magnetic poles 13 and 13a. Furthermore, by laminating a plurality of these stacked steel plates 4a, the plurality of small teeth 18 are stacked up forming long, narrow, straight protrusions and long, narrow grooves between adjacent protrusions.

[0035] In a state where a stator stack 4 that has been assembled in this manner and has just undergone abrasive finishing by means of mechanical processing, trimming burrs that arise in the process of punching for forming this shape in the stacked steel plates remain. Furthermore, after a plurality of these stacked steel plates 4a has been turned, stacked and laminated, processing burrs arise on the peripheral edges of the small teeth 18 of each of the stacked steel plates 4a because of the honing process performed to eliminate irregularities in the dimensions of the inside diameter. Therefore, in order to remove these trimming burrs and processing burrs that

remain on the small tooth surfaces of each of the stacked steel plates 4a of the stator stack 4, the stator stack 4 finishing method described in the following is implemented in the first embodiment.

[0036] More specifically, in this finishing method, a high pressure liquid jet spray nozzle 20 is introduced into the central cylindrical cavity 5 of the stator stack 4 which has undergone abrasive finishing by means of a mechanical process, such as honing or grinding as shown Figs. 2 and 3; and while this high pressure liquid jet spray nozzle 20 is moved relatively along the central axis of the central cylindrical cavity 5 and rotated relatively around the central axis of the central cylindrical cavity 5, the high pressure liquid jet 21 sprayed from the two jet orifices on opposite sides of the high pressure liquid jet spray nozzle 20 strikes the small tooth surfaces of each stacked plate 4a of the stator stack 4 facing the central cylindrical cavity 5, thus removing any burrs remaining on these small tooth surfaces.

[0037] Burrs, such as trimming burrs and processing burs, that remain on the surfaces on the peripheral edges of the small teeth 18 of each stacked steel plate 4a are sprayed from the jet orifices of the high pressure liquid jet spray nozzle 20, effectively dislodged, sent flying and removed by the strong force of impact of the high pressure liquid jet 21, which is set to an appropriate pressure. Furthermore, the waste, oil, metal dust and crystalline material adhering to the small tooth surfaces can be effectively blown away and the tooth surfaces cleaned. And, since there is no cause of dulling particularly of the angles of the parts 18a of the small teeth 18 where both angles are punched at approximately right angles (see Fig. 4), there is no fear of distortion in the motor rotation characteristics such as torque, angular precision,

hysteresis characteristics, vibration and response frequency. In fact, improvements in such characteristics is frequently observed.

[0038] By carrying out this finishing process on stator stacks 4 of stepping motor 1, the finishing process can be performed using a comparatively simple method with a reduced work time. It is also possible to provide a good finishing without creating poor rotation of the motor 1 where the removed burrs, etc., lodge between the laminates of the plural stacked steel plates 4a that form the stack 4, fly out during motor 1 rotation and lodge in between the stator and the rotor.

[0039] In order to move and rotate the high pressure liquid jet spray nozzle 20 and the stator stack relative to each other, it is also acceptable to hold the stator stack 4 in a jig and then move and rotate it, while it is further acceptable to rotate the high pressure liquid jet spray nozzle 20 and move the stator stack 4 or do the reverse of this.

[0040] Furthermore, the orientation of the high pressure liquid jet 21 is perpendicular to the axis of the high pressure liquid jet spray nozzle 20 therefore perpendicular to the central axis of the center cylindrical cavity 5. However, it is also acceptable for it to be slanted at a certain angle α (see the dashed line in Fig. 2). Such a method prevents the high pressure liquid jet 21 from being forced into the spaces between each of the layers in the plurality of stacked steel plates 4a and from making these spaces larger due to the strong force of impact, and therefore prevents the dislodged burrs, etc., from easily entering the spaces in the laminates. Furthermore, if the orientation of the spray of the high pressure liquid jet 21 is toward the trimming burrs in particular, the burrs can be easily removed.

[0041] Moreover, the number of jet orifices on the high pressure liquid jet spray nozzle 20 is not limited to a particular number. One jet orifice will suffice, however, when there are a plurality of jet orifices in accordance with the number of magnetic poles 13, all of the small tooth surfaces can be finished and cleaned at the same time, uniformly and instantly with just a relative rotation of the high pressure liquid jet spray nozzle 20. In such a manner, it is possible to improve work efficiency and obtain good finishing. Furthermore, if there is an even number of jet orifices in point symmetry in this case, the reactive motion of the jet spray is balanced, and the work can be performed with even greater efficiency.

[0042] Water is normally used for the high-pressure liquid jet 21, but pure water may be used instead of water. When pure water is used, the need to further clean the stator stack 4 in order to remove the spray liquid after finishing is eliminated. Consequently, there is no buildup, corrosion or clogging of the high pressure liquid jet spray nozzle 20 and the high pressure pipes due to various ions and impurities contained in city water. As such, prevention of rust after finishing is also possible.

[0043] According to experiments using water for the high pressure liquid jet 21 with a high pressure liquid jet spray nozzle 20 jet orifice diameter of 0.10 – 0.25 mm, a spray pressure of 500 – 1500 kgf/cm^2, a stator stack rotation of 240 rpm, a speed of 1 mm/s for the speed of movement of the high pressure liquid jet spray nozzle 20, a distance of approximately 2mm between the high pressure liquid jet spray nozzle 20 and the stator stack 4, a spray orientation for the high pressure liquid jet 21 perpendicular to the central axis of the central cylindrical cavity 5 and having the high pressure jet spray nozzle 20 make one pass back and forth, good finishing with removal

of the burrs remaining on the small tooth surfaces was obtained. In addition, there was no dulling of the small teeth 18.

[0044] In accordance with a second embodiment of the present invention, as shown in Figs. 5 and 6, the rotor stack 6, where the rotor stack finishing method is used, is formed by laminating a plurality of steel plates 6a made from disks of magnetic material with a plurality of small teeth 22 formed at equal intervals around the outside perimeter. Long narrow protrusions are formed by the stacking of a plurality of these small teeth 22 by means of laminating a plurality of the stacked steal plates 6a, and long narrow grooves are formed between adjacent protrusions.

[0045] In a state where a rotor stack 6 assembled in this manner and has just undergone abrasive finishing by means of mechanical processing, the trimming burrs that arise in the process of punching for forming this shape in the stacked steel plates remain. Furthermore, after a plurality of these stacked steel plates 6a has been laminated, processing burrs arise on the peripheral edges of the small teeth 22 of each of the stacked steel plates 6a because of the grinding process performed to eliminate irregularities in the dimensions of the outside diameter. Therefore, in order to remove these trimming burrs and processing burrs that remain on the small tooth surfaces of each of the stacked steel plates 6a of the rotor stack 6, the rotor stack 6 finishing method described in the following is implemented in the second embodiment.

[0046] More specifically, in this finishing method, high pressure liquid jet spray nozzle 30 is moved back and forth relative to the rotor stack 6 along the central axis of the aforementioned rotor stack 6 which has undergone abrasive finishing by means of a mechanical process as shown in Figs. 5 and 6 and while this high pressure liquid jet

spray nozzle 30 is moved relatively along the central axis of the rotor stack 6 and rotated relative to the rotor stack 6, the high pressure liquid jet 31 sprayed from the jet orifice on the high pressure liquid jet spray nozzle 30 strikes the small tooth surfaces from directly above the small teeth 22 of the rotor stack 6, thus removing any remaining burrs.

[0047] Burrs, such as trimming burrs and processing burs, that remain on the surfaces on the peripheral edges of the small teeth 22 of each stacked steel plate 6a are sprayed from the jet orifices of the high pressure liquid jet spray nozzle 30, effectively dislodged, sent flying and removed by the strong force of impact of the high pressure liquid jet 31, which is set to an appropriate pressure. Furthermore, the waste, oil, metal dust and crystalline material adhering to the small tooth surfaces can be effectively blown away and the tooth surfaces cleaned. And, since there is no cause of dulling particularly of the angles of the parts 22a of the small teeth 18 where both angles are punched at approximately right angles (see Fig. 8), there is no fear of distortion in the motor rotation characteristics, such as torque, angular precision, hysteresis characteristics, vibration and response frequency. In fact, improvements in such characteristics is frequently observed.

[0048] By carrying out this finishing process on rotor stacks 6 of stepping motor 1, the finishing process can be performed using a comparatively simple method with a reduced work time. It is also possible to provide a good finishing without creating poor rotation of the motor 1 where the removed burrs, etc., lodge between the laminates of the plural stacked steel plates 6a that form the stack 6, fly out during motor 1 rotation and lodge in between the stator and the rotor.

[0049] In order to move and rotate the high pressure liquid jet spray nozzle 30 and the rotor stack 6 relative to each other, it is also acceptable to hold the rotor stack 6 in a jig and then move and rotate it, while it is further acceptable to move the high pressure liquid jet spray nozzle 30 and rotate the rotor stack 6 (see Fig. 5) or do the reverse of this.

[0050] Furthermore, the orientation of the high pressure liquid jet 31 spray is perpendicular to the axis of the rotor stack 6. However, it is also acceptable for it to be slanted at a certain angle α (see the dashed line in Fig. 5). Such a method prevents the high pressure liquid jet 21 from being forced into the spaces between each of the layers in the plurality of stacked steel plates 6a and from making these spaces larger due to the strong force of impact, and therefore prevents the dislodged burrs, etc., from easily entering the spaces in the laminates.

[0051] However, the positions where the high-pressure liquid jet 31 strikes the rotor stack 6 small teeth 22 may be changed as follows.

[0052] More specifically, the high pressure liquid jet 31 sprayed from the high pressure liquid jet spray nozzle jet orifice is oriented tangentially to the rotor stack 6 as shown in Fig. 7 and strikes the small tooth surfaces of the rotor stack from the side. In such a case, it is desirable if the small teeth 22 are struck from the opposite direction (see the dashed lines in Fig. 7) because the burr removal is more effective. In such a case the relative movement and rotation of the high pressure liquid jet spray nozzles 30 and the rotor stack 6 are the same as in the case of Figs. 5 and 6.

[0053] According to experiments using water for the high pressure liquid jet 31 with a high pressure liquid jet spray nozzle 30 jet orifice diameter of 0.25 – 0.40 mm,

a spray pressure of 500 – 1500 kgf/cm^2, a rotor stack rotation of 240 rpm, a speed of 1 mm/s for the speed of movement of the high pressure liquid jet spray nozzle 30, a distance of approximately 30 mm between the high pressure liquid jet spray nozzle 30 and the rotor stack 6, a spray orientation for the high pressure liquid jet 31 perpendicular to the central axis of the rotor stack and having the high pressure jet spray nozzle 30 make one pass back and forth, good finishing with removal of the burrs remaining on the small tooth surfaces was obtained. In addition, there was no dulling in the small teeth 22.

[0054] Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.